Feed-a-Gene

Adapting the feed, the animal and the feeding techniques to improve the efficiency and sustainability of monogastric livestock production systems

Feed-a-Gene seminar associated with annual FEFAC meeting

FEFAC

EU produced alternatives to reduce EU's dependency on soya bean import for the animal feed industry :

Nutritive value of partly defatted soybean meals

Eric Royer[1], Patrick Carré[2], Veronika Halas[3], Panagiotis Sakkas[4], Paul Bikker[5], Alain Quinsac[6], Ilias Kyriazakis[4], Knud Erik Bach Knudsen[7],

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ifip institut du porc

OLEAD

KAPOSVÁRI EGYETEM

Newcastle University

WAGENINGEN UNIVERSITY & RESEARCH

Terres Inovia l'agronomie en mouvement

AARHUS UNIVERSITY

9 October, 2019

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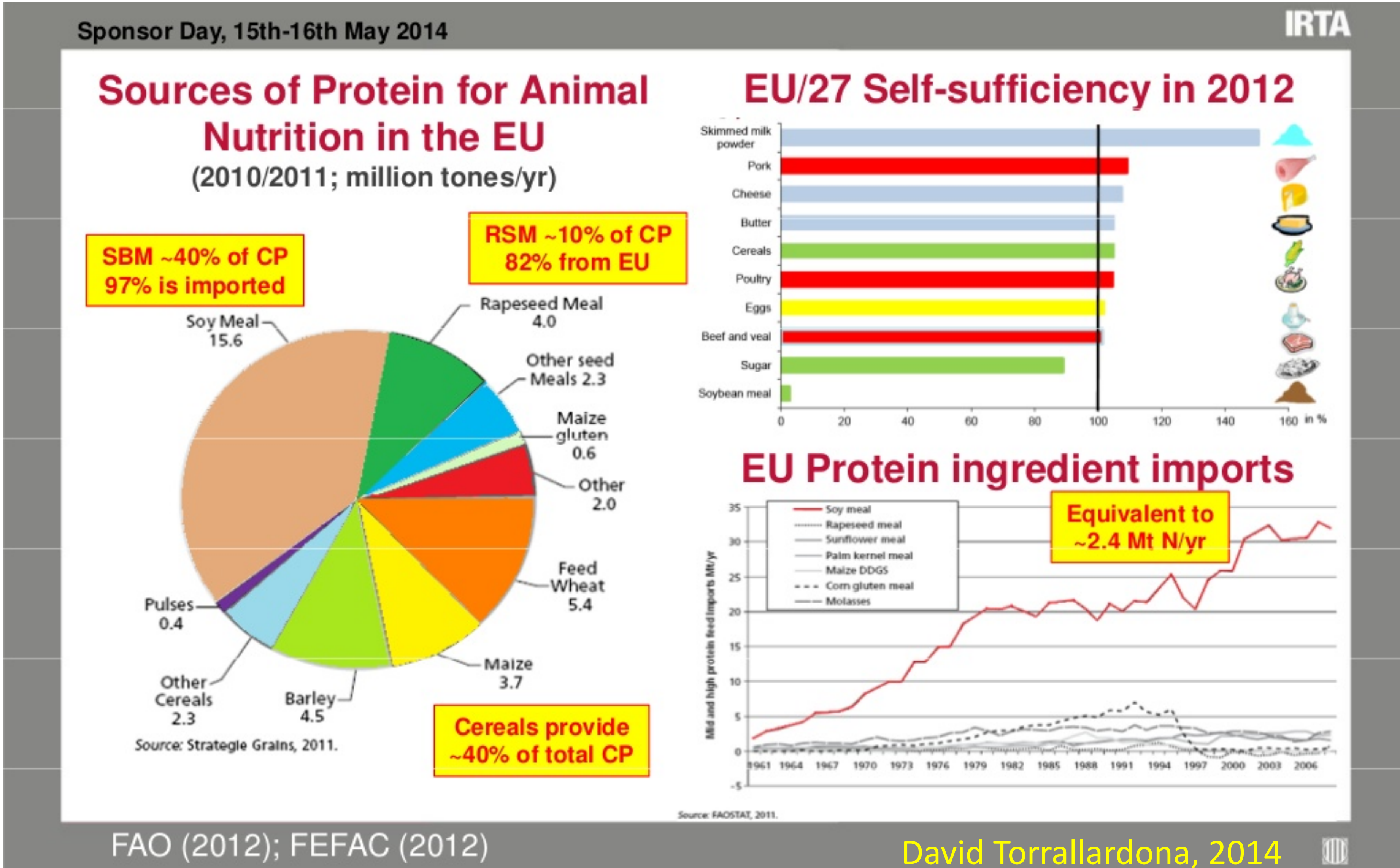
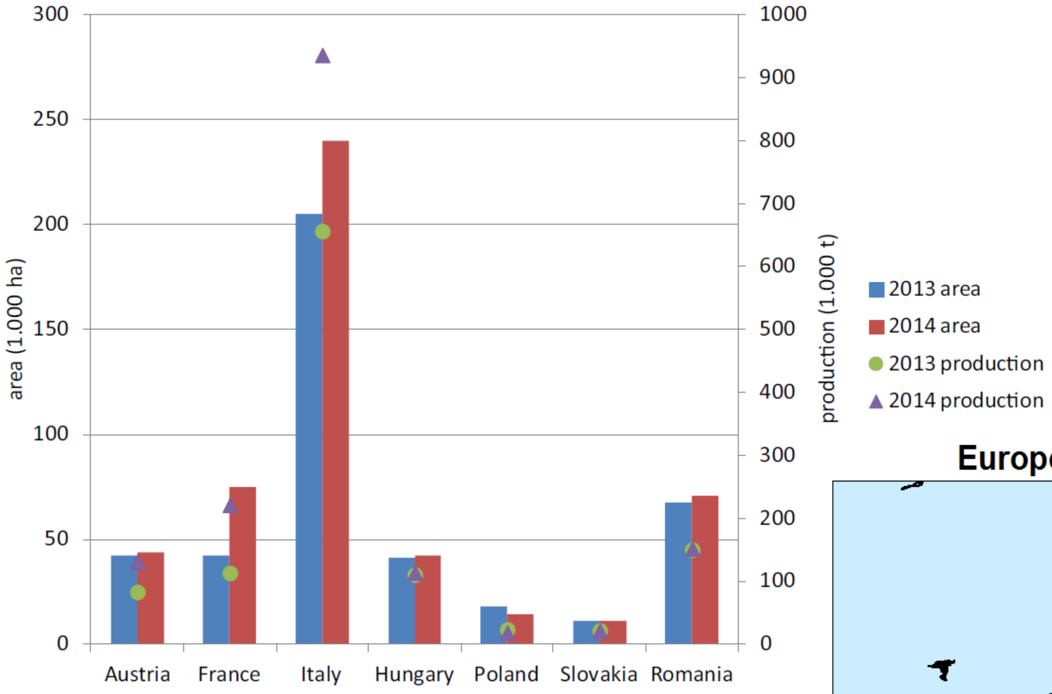
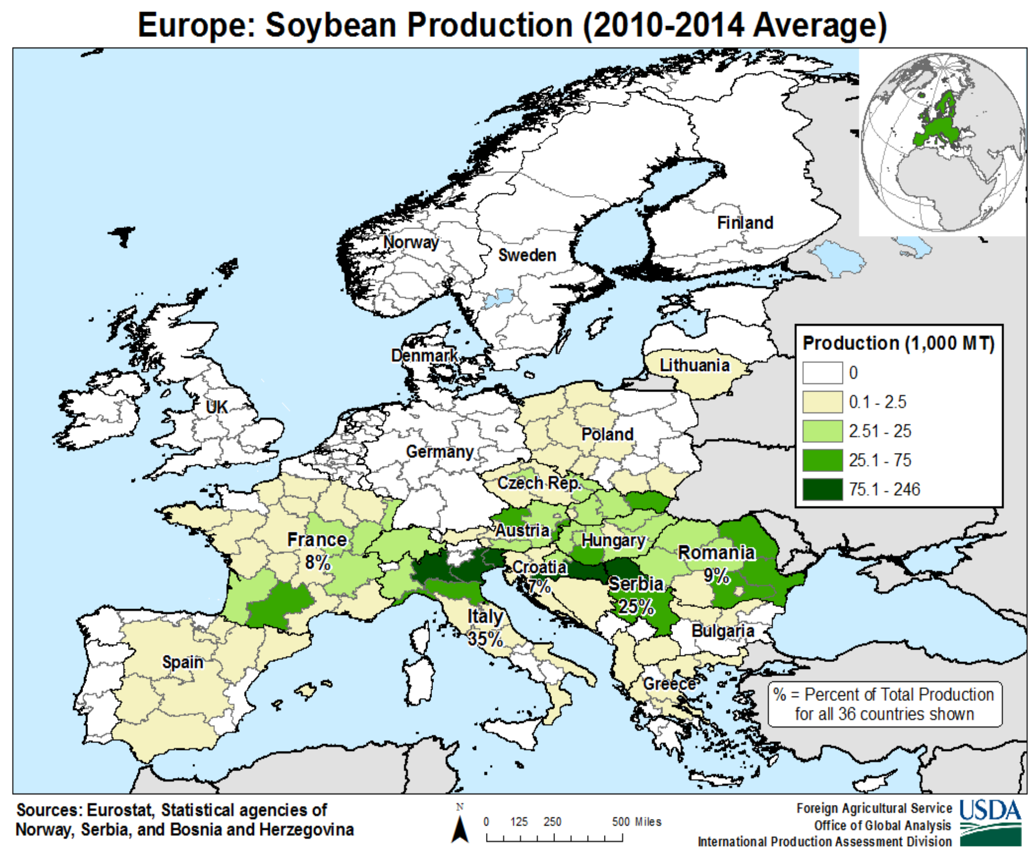
Context


Sponsor Day, 15th-16th May 2014
IRTA
Sources of Protein for Animal Nutrition in the EU
(2010/2011; million tones/yr)
SBM ~40% of CP
97% is imported
RSM ~10% of CP
82% from EU
Soy Meal 15.6
Rapeseed Meal 4.0
Other seed Meals 2.3
Maize gluten 0.6
Other 2.0
Feed Wheat 5.4
Maize 3.7
Barley 4.5
Other Cereals 2.3
Pulses 0.4
Source: Strategie Grains, 2011.
Cereals provide
~40% of total CP
EU/27 Self-sufficiency in 2012
Skimmed milk powder
Pork
Cheese
Butter
Cereals
Poultry
Eggs
Beef and veal
Sugar
Soybean meal
0
20
40
60
80
100
120
140
160
in %
EU Protein ingredient imports
Equivalent to
~2.4 Mt N/yr
Soy meal
Rapeseed meal
Sunflower meal
Palm kernel meal
Maize DDGS
Corn gluten meal
Molasses
Mid and high protein feed imports Mt/yr
1961
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
Source: FAOSTAT, 2011.
FAO (2012); FEFAC (2012)
David Torrallardona, 2014

Context : European soybean crops



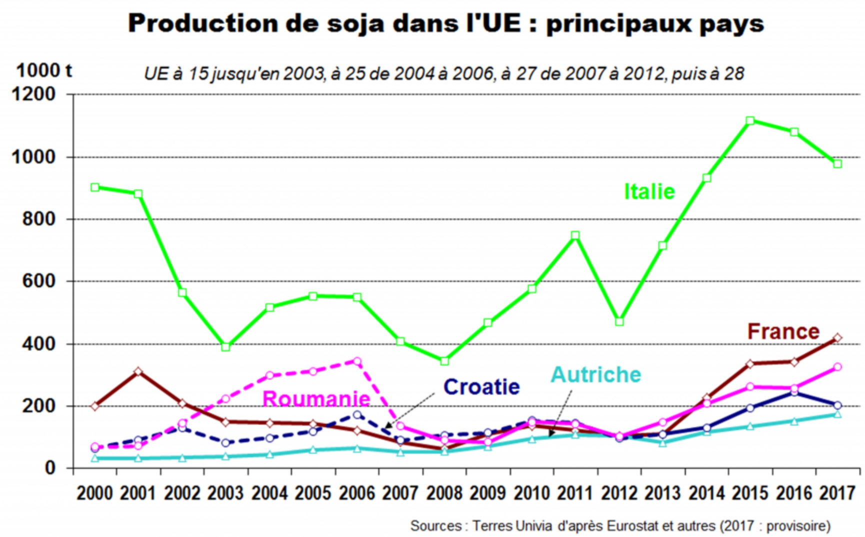
- Main EU soybean-producing countries (> 10000 ha)
- source: Copa-Cogeca.

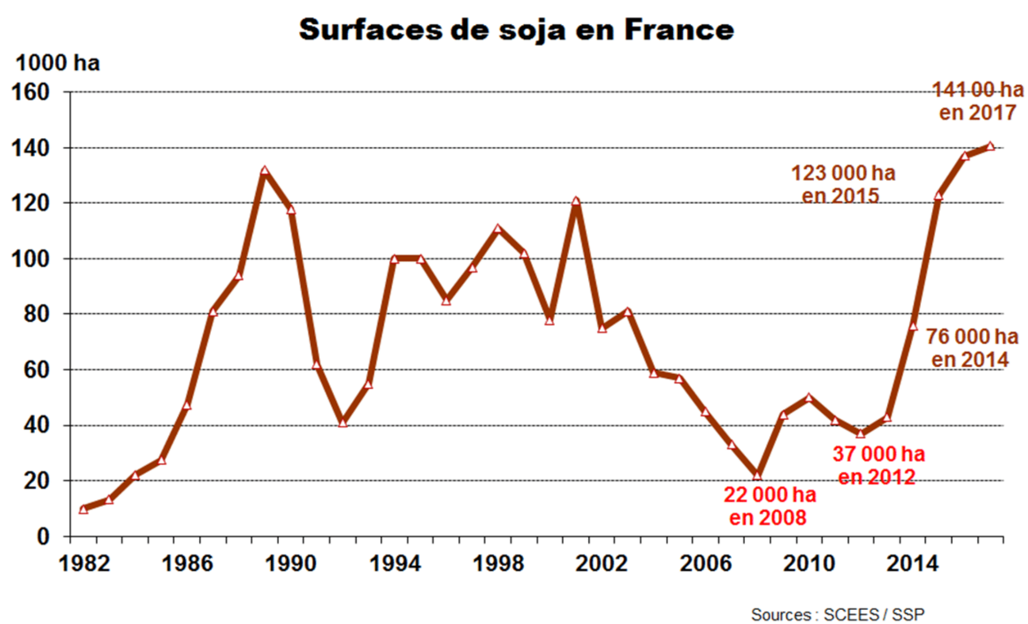


Feed-a-Gene

Adapting the feed, the animal and the feeding techniques
to improve the efficiency and sustainability of monogastric livestock production systems

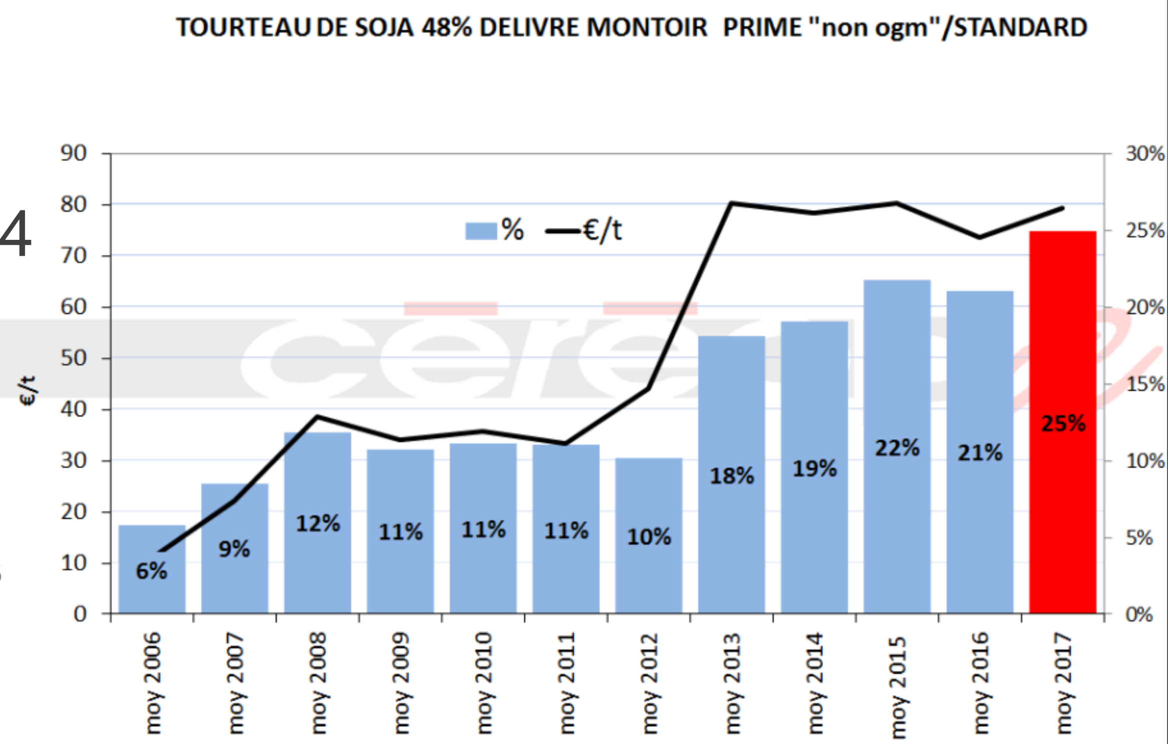
Context : Evolution of European soy surfaces



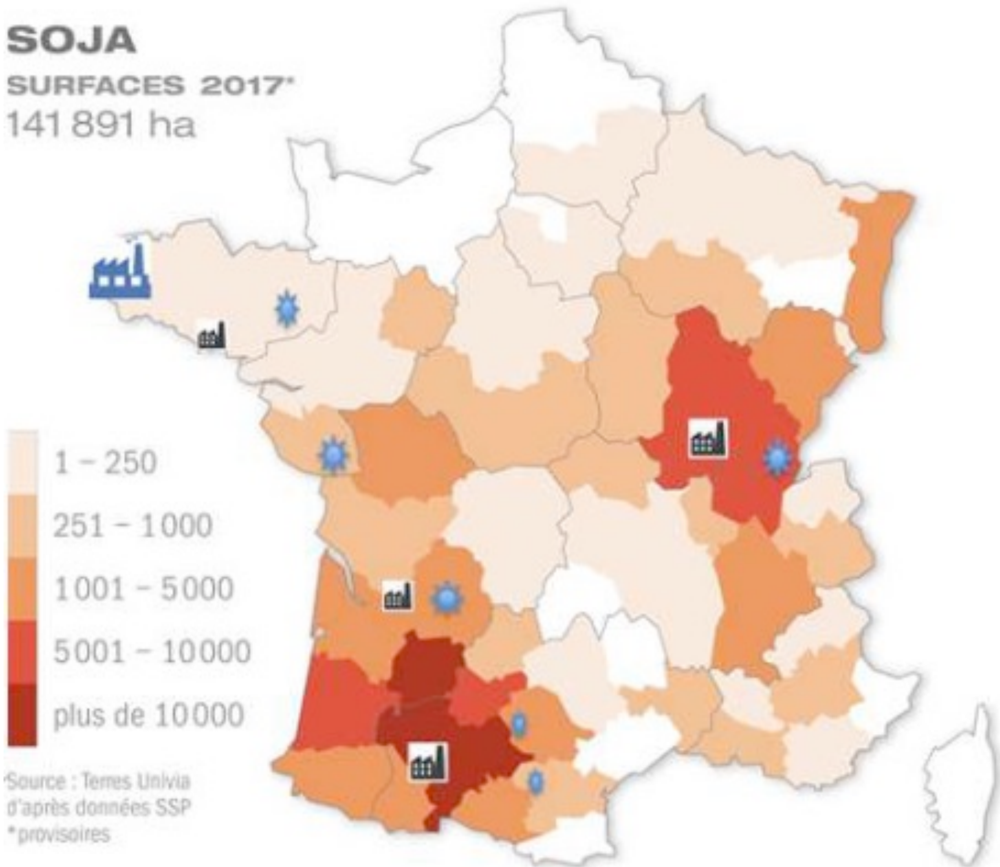


Context : ↗ demand for non-GM soybean

- EU 2015
  - Non-GM ≥ 10% of soybean equivalent imported into EU (3.4 Mt) [EU Joint report 2015]
- France 2019
  - Non-GM = 15% ; .45 Mt, 200 000 ha [Terres Univia, 2019]



Context: new local crushing plants



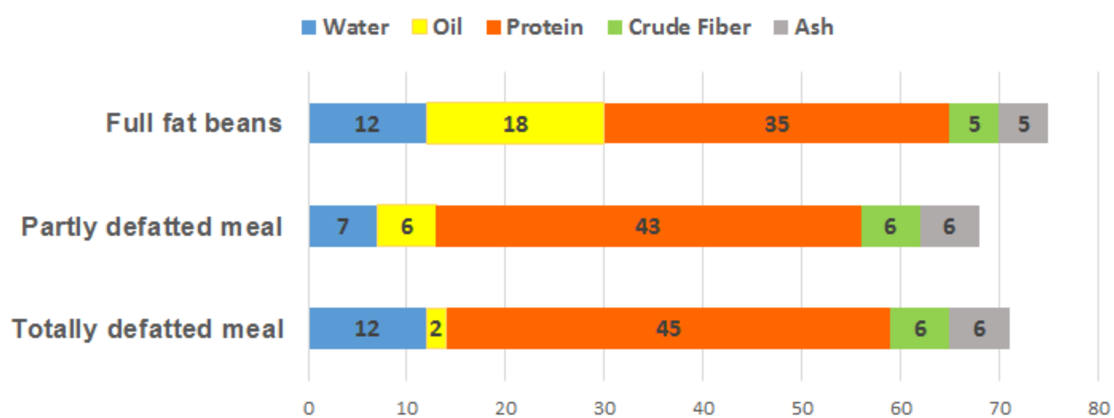
Standard crushing plant

Local crushing plant

Extrusion unit or similar

Study context: process of soybean meals

- Main goal: inactivation of trypsin inhibitors (TI)
  - Full fat beans = extruded or toasted
  - Partly defatted soymeal = thermal treatment + pressing
  - Totally defatted soymeal = solvent extraction



Quinsac et al, 2014

- Processing of soybeans in medium-sized crushing plants from local and GMO-free crops
  - nutritional and economic values ?

Study context : methods to process soymeal

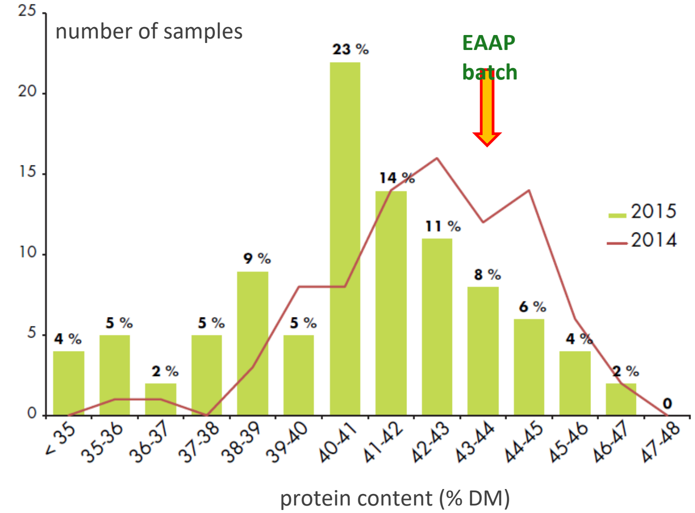
- Which process for partly defatted soymeals ?
  - Heat treatments before pressing
    - Extrusion-Pressing (EP) vs Flaking-Cooking-Pressing (FCP)
      - Similar costs, well-known technologies
      - Better TI inactivation with FCP
      - Better oil extraction with EP
      - Partial performance results for EP (chicken), not for FCP
      - Incorporation % and interest price in diet formulations ?
  - Effect of dehulling on CP % and digestibility ?

FaG study: evaluate extrusion-pressing & flaking-pressing-cooking with European soybeans

- One batch of soybeans → 2 x 2 factorial design → 4 products
  - extrusion-pressing (EP) vs. flaking-cooking-pressing (FCP)
  - preparation of beans with dehulling (D) or not (WB)
  - *effects of process factors (preparation, temperature) + variations of flow rate/speed + specific mechanical energy*
- Composition and nutritive values
  - chemical values
  - in vitro rate of degradation (pH-Stat)
  - amino acids & reactive lysine contents
  - NIR
- Animal studies: piglets + broiler chicks

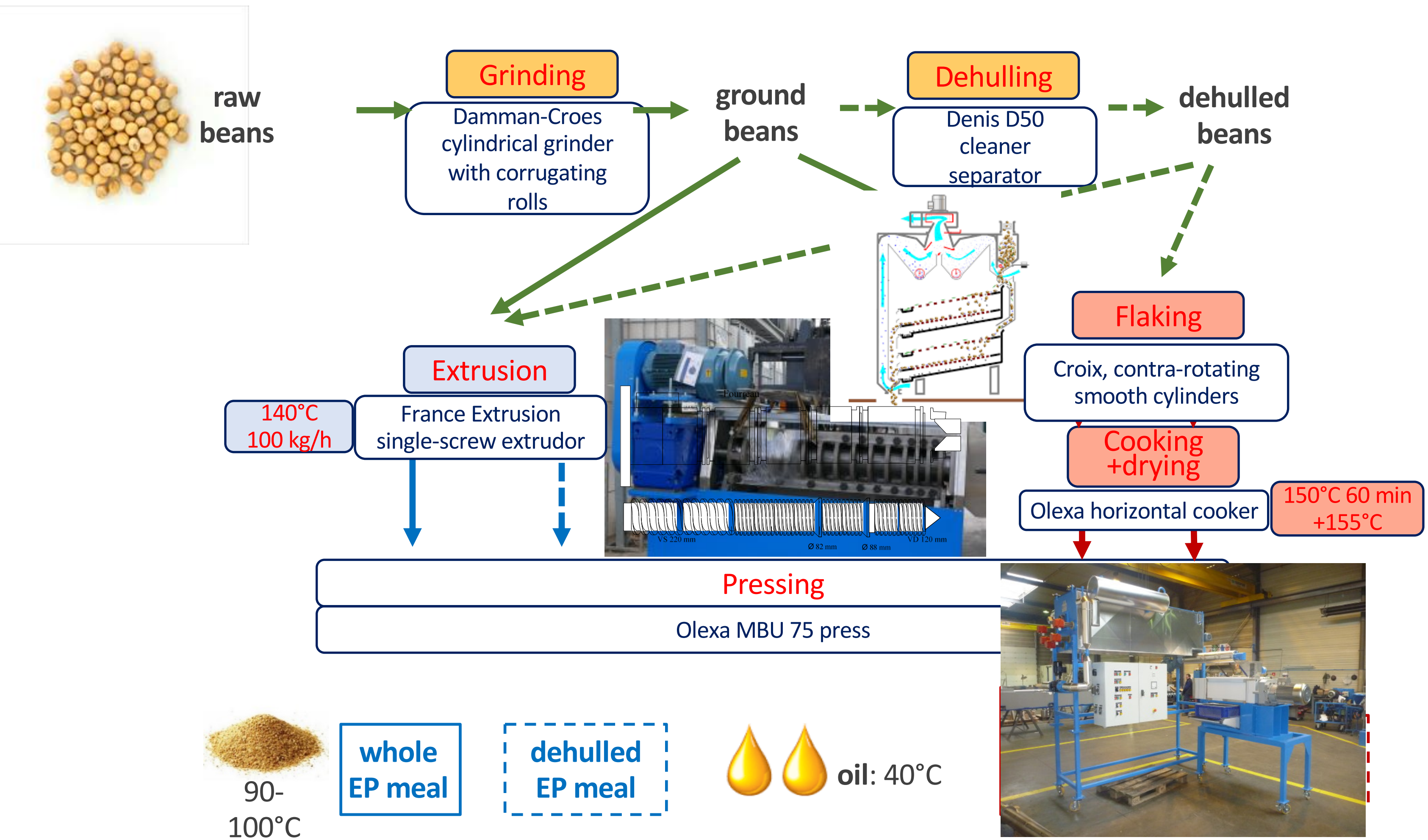
- Origin of the raw beans
  - 1 batch of 2015 crop
  - CP = 44 % DM

- Protein % of French harvest in 2014 & 2015



	Crude Fiber	Water content	Oil soxlhet	Proteins Kjeldahl	KOH sol. Proteins	Solubility	Trypsin In Un.
	(%/DM)	(%)	(%/DM)	(%/DM)	(%/DM)	%	TIU /mg
EAAP batch	5.6	13.4	20.5	44.3	42.1	95.0	25
France 2015 survey		13.2	21.4	40.7			
Feedipedia base	6.2	11.3	21.4	39.6			

OLEAD


raw beans
Grinding
Damman-Croes cylindrical grinder with corrugating rolls
ground beans
Dehulling
Denis D50 cleaner separator
dehulled beans
Flaking
Croix, contra-rotating smooth cylinders
Cooking +drying
Olexa horizontal cooker
150°C 60 min +155°C
Extrusion
140°C 100 kg/h
France Extrusion single-screw extrudor
Pressing
Olexa MBU 75 press
90-100°C
whole EP meal
dehulled EP meal
oil: 40°C

Results : Soymeal experimental products

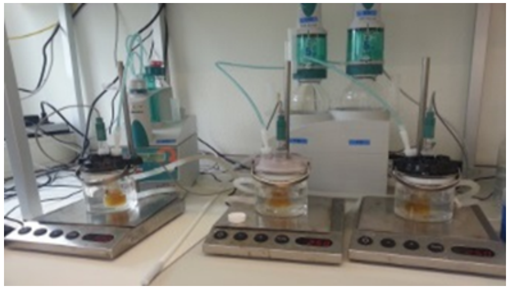
- Chemical composition characteristics

Study results	Dry Matter	Oil	Proteins		Protein solubility	Crude Fiber	Trypsin inhibitors
	% on crude weight basis			*% de-oiled DM*	*% on crude*		*TIU / mg*
Raw soybean	87	18	38	55.7	95	5	25
FCP-whole beans	91	8	47	55.8	82	5	3.6
EP-whole beans	94	5	50	56.0	70	6	2.6
FCP-dehulled	92	6	51	58.4	89	3	7.6
EP-dehulled	94	5	52	58.8	76	3	3.5

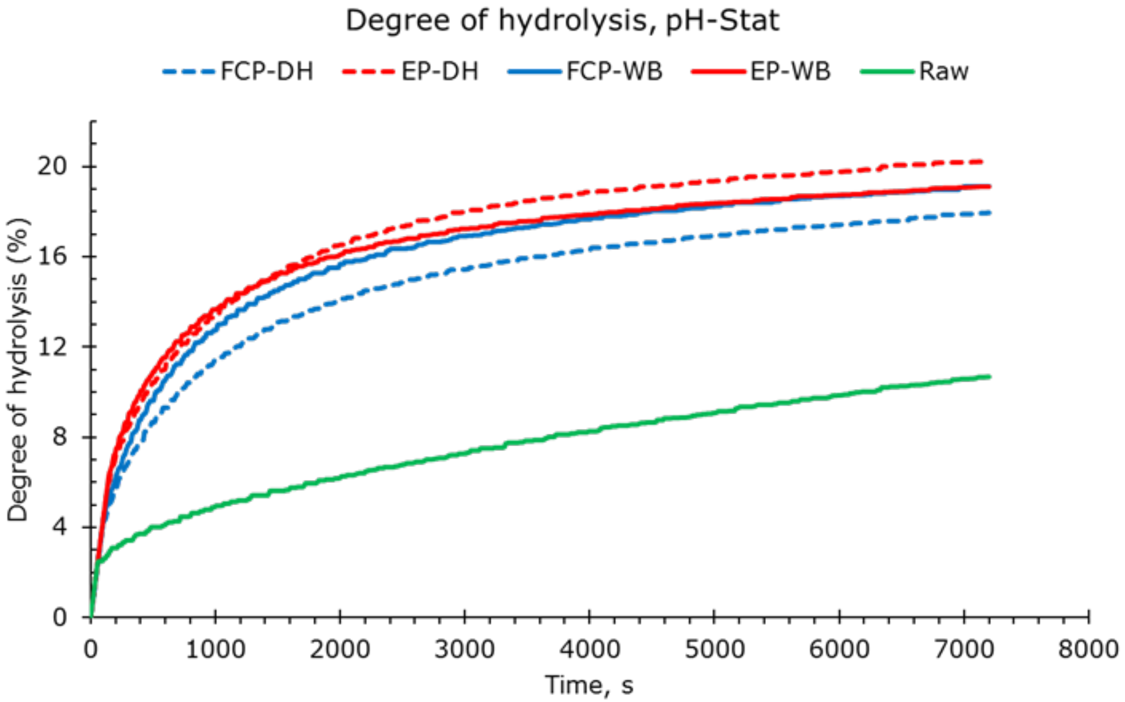
≠ 7°C at dryer exit

EP vs FCP impact	-3.2	+ 3.6	+ 0.2	whole beans
	-1.1	+ 1.8	+ 0.3	dehulled beans
dehulling impact	-1.9	+ 3.9	+ 2.7	with FCP process
	+ 0.2	+ 2.2	+ 2.8	with EP process

Results : pH-stat method



- Evolution of the hydrolysis degree of peptid bonds



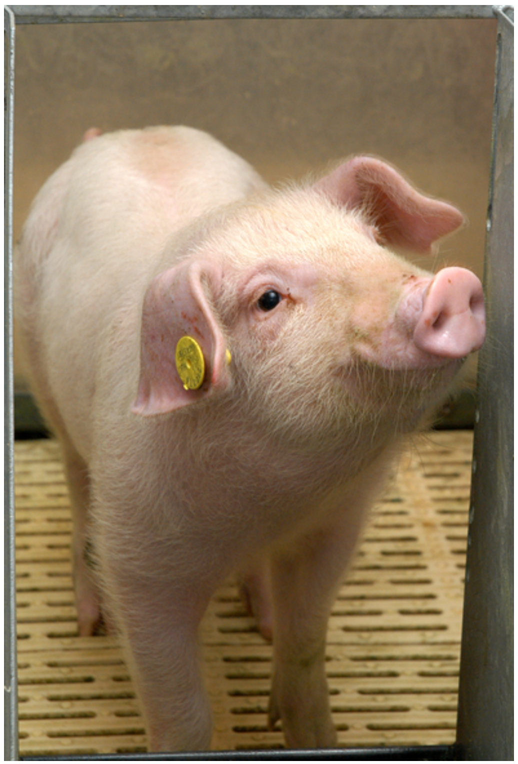
Discussion of production trial

- Good quality products :
  - CP ≈ 50 % as basis, solubility 70-90 %
- Higher content of trypsin inhibitors for FCP-D : 7.6 UTI/mg
  - Slightly undercooked : can easily be modified.
  - In pre-trial with same beans : no meal ≥ 4,4 UTI / mg.

Soybean experimental products

SBM production analysis & routing

KAPOSVÁRI EGYETEM



Determination of AID and SID of AAs in European soya products with weaned pigs

V. Halas
Kaposvár University

WP1	Task: 1.4 - KU
Aim	To determine amino acid digestibility of European soy protein products
Animal model	post mortem study with intact piglets (12-28 kg)
Short description of the experimental design	A total of 2 x 35 intact piglets, 7 treatments , 2 replicates, n=5 x 2 4 weeks performance test, 5 days metabolic study + post mortem digesta sampling
Treatment groups	Soya products with different processes from T1.1 Trt 1: N-free diet Trt 2: Good quality SBM (CP>48%; control) Trt 3-6: European soya product (FCP vs. EP and dehulled vs whole) Trt 7: Casein diet
Response measures	Body weight, feed intake, FCR – 4 weeks trial Apparent and standardized ileal digestibility of amino acids Analysis from feed: proximate analysis, titanium dioxide (marker), amino acids, Ca and P, gross energy in raw materials and mixed feeds From ileal digesta: DM, titanium dioxide, nitrogen, amino acids From feces: proximate analysis, titanium dioxide, gross energy, P
Dietary protein	180g crude protein/kg, Iso-nitrogenous diets in trt 2 to 7 Use the test ingredients as a solei protein source.

Experimental design and time line

Body weighing, *Start of experiment*

Performance trial - 4 weeks
- Feed intake *ad libitum*

Body weighing

Retention study - 5 days
- Feed intake: 90% ad libitum
- Fecal and urine collection

Body weighing, *post mortem* digesta sampling

Performance trial - 4 weeks	Retention study - 5 days
Trt A: control (comercial) SBM	N-free diet
Trt A: control (comercial) SBM	
Trt B: FCP dehlluled soybean	
Trt C: EP dehulled soybean	
Trt D: FCP whole soybean	
Trt E: EP whole soybean	
Trt F: casein	

FCP: flaking cooking pressing
EP: extrusion pressing

KU studies with piglets

Composition and nutrient content of the experimental feeds (g/kg)

	Control	FCP-d	EP-d	FCP-w	EP-w	Casein
Corn starch	482.7	542.60	555.2	508.9	533.7	624.1
Sugar	50.0	50.0	50.0	50.0	50.0	50.0
Soybean meal*	378.0	355.0	343.0	386.6	358.0	0
Casein	0	0	0	0	0	214.3
Arbocel	0	0	0	0	0	50.0
Sunflower oil	45.0	9.0	8.0	12.0	15.0	15.0
MCP	15.5	15.1	15.5	14.2	15.0	19.5
Limestone	8.5	8.0	8.0	8.0	8.0	8.0
NaCl	4.3	4.3	4.3	4.3	4.3	4.3
DL-Methionine	1.0	1.0	1.0	1.0	1.0	1.0
Premix 1.0%	10.0	10. 0	10. 0	10. 0	10. 0	10.0
Ti-dioxide	5.0	5.0	5.0	5.0	5.0	5.0
Total	1000	1000	1000	1000	1000	1000
DM	912	916	918	916	919	925
Crude protein	176	174	170	182	173	175
Ether exctract	50	37	26	44	32	14
Crude fiber	16	12	9	21	18	30

KU studies with piglets

Effect of dietary treatments on performance of weaning pigs

	Control	FCP-d	EP-d	FCP-w	EP-w	Casein				
n	10	10	10	10	10	13	RMSE	trt	R	Trt x R
BW0, kg	11.6	11.6	11.6	11.5	11.4	11.8	1.57	.998	.170	.994
BWf, kg	29.0[a]	20.6[b]	28.8[a]	27.5[a]	28.5[a]	20.76[b]	3.61	.0001	.263	0997
ADG, g/d	621[a]	322[b]	615[a]	572[a]	608[a]	323[b]	95.7	.0001	.022	.978
ADFI, g/d	1032[a]	894[ab]	879[ab]	944[a]	949[a]	749[b]	126.6	.0001	0.658	.0004
FCR, kg/kg	1.67[a]	2.96[b]	1.45[a]	1.66[a]	1.56[a]	2.81[b]	.840	.0001	.786	.422

Effect of dietary treatments on AID of amino acids

	Control	FCP-d	EP-d	FCP-w	EP-w	Casein				
n	10	6	8	10	10	6	RMSE	trt	R	Trt x R
Lys	.753^{b}	.725^{b}	.886^{a}	.876^{a}	.848^{a}	.918^{a}	.043	.0001	.036	.0001
Met	.766^{b}	.790^{b}	.920^{a}	.904^{a}	.903^{a}	.963^{a}	.039	.0001	.375	.0001
Thr	.695^{bc}	.647^{b}	.796^{a}	.808^{a}	.750^{ab}	.845^{a}	.055	.0001	.136	.0002
Leu	.738^{c}	.636^{d}	.874^{ab}	.850^{ab}	.831^{b}	.907^{a}	.046	.0001	.001	.0001
Ile	.694^{b}	.612^{c}	.850^{a}	.823^{a}	.799^{a}	.873^{a}	.054	.0001	.877	.0001
His	.773^{b}	.662^{c}	.842^{ab}	.826^{ab}	.798^{b}	.884^{a}	.047	.0001	.0001	.149
Val	.698^{c}	.628^{c}	.848^{ab}	.827^{ab}	.808^{b}	.906^{a}	.049	.0001	.021	.0001
Arg	.856^{c}	.771^{d}	.932^{a}	.919^{ab}	.912^{abc}	.882^{bc}	.040	.0001	.058	.009

Effect of dietary treatments on SID of amino acids

	Control	FCP-d	EP-d	FCP-w	EP-w	Casein				
n	10	6	8	10	10	6	RMSE	trt	R	Trt x R
Lys	.847^{b}	.819^{b}	.990^{a}	.965^{a}	.946^{a}	1.005^{a}	.043	.0001	.015	.0001
Met	.848^{b}	.872^{b}	1.00^{a}	.994^{a}	.985^{a}	1.004^{a}	.039	.0001	.375	.0001
Thr	.870^{cd}	.831^{d}	1.00^{ab}	.982^{ab}	.936^{bc}	1.035^{a}	.055	.0001	.010	.0001
Leu	.843^{b}	.743^{c}	.990^{a}	.953^{a}	.942^{a}	1.008^{a}	.046	.0001	.0001	.0001
Ile	.826^{b}	.749^{b}	.997^{a}	.954^{a}	.938^{a}	1.024^{a}	.054	.0001	.255	.0001
His	.908^{c}	.799^{d}	.996^{ab}	.957^{abc}	.937^{bc}	1.044^{c}	.047	.0001	.0001	.129
Val	.820^{c}	.754^{c}	.983^{ab}	.947^{ab}	.934^{b}	1.019^{a}	.049	.0001	.011	.0001
Arg	.929^{c}	.835^{d}	1.008^{ab}	.982^{bc}	.980^{bc}	1.062^{a}	.040	.0001	.025	.007

Discussion of piglet study

- Pig study → processing temperature of soy products → crucial for protein quality and the level of antinutritional factors (Webster et al., 2003, Quinsac et al., 2012, Karr-Lilienthal et al. al., 2006)
- In our study, use of soymeal as single source of protein ↔ a feed content of 2.7 TIU / mg close to the maximum value of 3.0 TIU / mg proposed for growing pig (Royer et al., 2015)

Effect on performance of starter and grower broiler chicks.

Panagiotis Sakkas
Newcastle University

Materials and Methods

- 288 birds in a 2x2 design: 2 methods of production (Extrusion pressing (EP) vs Flaking-pressing-cooking (FPC)) x (dehulled vs not dehulled).
  - Birds received coarse mash starter diets between d0-14 and grower diets between d15-28 of age which met or exceeded NRC recommendations .
- Formulated to have the same CP content deriving from the 4 SBM products.
  - SBM: 29-32 % in starter diet, 2-29 % in grower diet
  - Differences in AME of the 4 dietary treatments were covered by supplementation of soy oil.
  - Synthetic AAs were added to cover limiting EAA requirements at the same level on a digestible AA basis in the 4 feeding treatments.
  - Titanium dioxide (0.5%) as an marker.
- Measurements
  - 3 birds per pen – DM and CP digestibility and digesta viscosity.
  - 1 bird per pen- jejunum histology .
  - 1 additional bird (D28) per pen GIT development per segment and organ and carcass evaluation.

Results performance

		BW	ADFI			ADG			FCR		
Days of age		0	1-14	15-28	1-28	1-14	15-28	1-28	1-14	15-28	1-28
Process x Hull treatment											
EP	D	37.2	36.7[a]	110.3	73.5	27.5[a]	65.5	46.5	1.33	1.65	1.54[b]
	W	37.0	38.9[b]	111.4	75.1	29.1[b]	66.9	48.0	1.33	1.61	1.51[a]
FCP	D	37.0	37.6[ab]	112.2	74.9	28.8[ab]	67.2	48.0	1.30	1.64	1.52[ab]
	W	36.3	37.7[ab]	114.1	75.9	27.6[a]	68.9	48.2	1.37	1.62	1.54[b]
SEM		0.45	0.48	1.39	0.76	0.43	1.09	0.59	0.019	0.025	0.018
Process		0.341	0.705	0.116	0.184	0.832	0.114	0.157	0.783	0.965	0.965
Hull		0.298	**0.032**	0.295	0.104	0.660	0.186	0.164	**0.094**	0.279	0.814
Process*Hull		0.571	**0.043**	0.758	0.698	0.004	0.913	0.293	**0.090**	0.709	**0.018**

Results Digestibility

Effect of soybean treatment on DM and CP digestibility at the end of the starter (d14) and finisher period (d28).					
		DM		CP	
Days of age		d14	d28	d14	d28
Process x Hull treatment					
EP	De-hulled	72.3	72.8	84.3	85.5
	Whole	69.5	72.7	84.0	86.0
FCP	De-hulled	71.7	72.0	82.5	83.0
	Whole	70.5	72.6	82.3	84.3
SEM		1.51	1.64	0.90	1.30
Source		Probabilities			
Process		0.906	0.785	0.069	0.118
Hull		0.201	0.877	0.778	0.486
Process*Hull		0.615	0.861	0.958	0.751

Results Carcass

Effect of soybean treatment on carcass yield and carcass part yield at d28 of age.					
		Carcass yield (%)	Breast (%)	Wing (%)	Thigh (%)
Process x Hull treatment					
Extrusion	De-hulled	68.9	34.0	11.5	27.5
	Whole	65.3	33.2	11.9	28.8
Flaking	De-hulled	68.9	33.6	11.5	27.3
	Whole	66.7	34.6	11.8	27.6
SEM		1.12			
Source		Probabilities			
Process		0.616	0.540	0.936	0.294
Hull		0.023	0.909	0.342	0.260
Process*Hull		0.550	0.342	0.963	0.483

Results GIT

Effects of soybean treatment on intestinal segment length and weight relative to eviscerated carcass weight at d28 of age (cm/kg and g/kg, respectively).							
		Duodenum length	Jejunum length	Ileum length	Duodenum weight	Jejunum weight	Ileum weight
Process x Hull treatment							
EP	De-hulled	27.5	69.0	72.8	10.1	18.6	15.8
	Whole	28.4	71.6	72.9	12.3	22.2	17.5
FCP	De-hulled	29.4	72.2	76.0	10.6	19.0	17.5
	Whole	31.7	75.0	78.5	10.6	20.7	15.4
SEM		2.09	4.29	5.15	0.67	0.96	0.99
Source		Probabilities					
Process		0.225	0.447	0.315	0.387	0.564	0.852
Hull		0.449	0.532	0.762	0.123	**0.012**	0.858
Process*Hull		0.732	0.985	0.784	0.127	0.346	0.067

Discussion of chicken study

- Both technologies equally promoted broiler performance over the starter and grower periods.
- Differences in KOH solubility and TIU levels were poor predictors of DM and CP digestibility.
- Hulled products resulted in similar performance-but lower carcass yield.
- Wheat based-contribution of hulls to viscosity small in comparison
- Furthermore offered as mash rather than pellets-gizzard development may facilitated DM and CP digestibility.

Discussion : effects of process

- All 4 process
  - Robust processes, efficient to inactivate TI
  - High quality products : DM, Fat, protein solubility and TI as expected (Creol, 2010)
  - High protein % : effect of batch ?
- EP vs FCP
  - Better defatting with EP
    - Similar to 2012 French survey (Onidol et al, 2012)
  - Higher CP with EP
    - EP = FCP in 2012 French survey
  - Lower protein solubility with EP, as expected
- Dehulling
  - ↗ CP % and protein solubility, ≃ fat %
  - Interaction between DH and process to confirm ?

Discussion : effects of processing variables

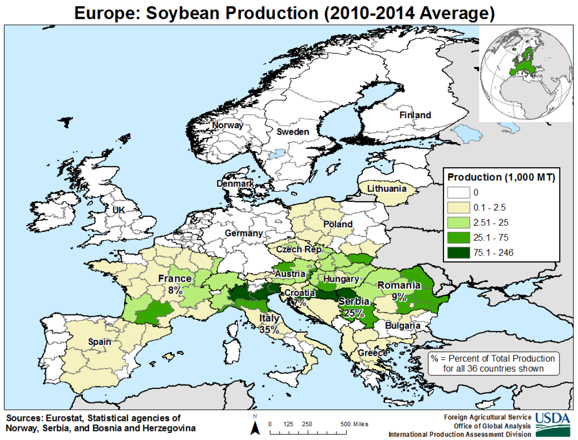
- Extruded-pressed SBs
  - Variation in EP SBs quality (Reese & Bitney, 2000)
  - Differences in AA composition and protein quality of SBs from 7 U.S. EP plants (Karr-Lilienthal et al, 2006)
  - AA dig from EP SBs > solvent SMB (Woodworth et al, 2001; Baker & Stein, 2009) ≠ Opapeju et al (2006)
    - Related to oil content ? (Cervantes-Pahm & Stein, 2008)
- Effect of process parameters
  - ↗ Extrusion °C ⇒ ↗ protein %, ↘ fat & TI % and protein quality (Webster, 2003)
    - Study optimal °C = 140 °C ≤ previous results = 150°C (Webster, 2003; Quinsac et al, 2005; Karr-Lilienthal et al, 2006)

Perspectives and conclusions

- Local soybean meal sources
  - Identity preservation since 1990 (USA)
  - Some EP plants in France & Italy (organic soy)
    - Specialized, better gross margin (Onidol, 2012)
  - Two FCP plants in France
    - Flexible for other oilseeds
- Suitable context for local plants (Labalette et al, 2013)
  - SB production far from large plants & importing ports
  - Significant labelled animal production ➔ switch to local protein
  - Value ↔ premium that actors will accept to pay
- Main market for poultry ? (Le Cadre, 2014)

Feed-a-Gene

Adapting the feed, the animal and the feeding techniques to improve the efficiency and sustainability of monogastric livestock production systems



Thank you !

- Markets
  - Françoise Labalette — Terres Univia, Paris
- Soy beans evaluation and process
  - Jean-Philippe Loison — Olead, Pessac
  - Mohammed Krouti — Terres Inovia, Ardon
  - Piet van Wikselaar — Wageningen UR
- Animal studies
  - Sheralyn Smith, Idieberagnoise Oikeh, — Newcastle University
  - János Tossenberger, Gergő Sudár — Kaposvár University